A REVIEW OF SYN-GAS POLYGENERATION AS ONE OF SOLUTIONS TO SOLVE NATIONAL ENERGY CRISIS

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ABSTRACT

In the future, Indonesian crisis energy can be overcome by the use of coal as oil substitute. Substituting oil by coal is still a problem due to unfamiliar using coal by Indonesian, inappropriate technology selection and environmental pollution. The use of coal-based syn-gas as various energy resources and chemical material can be conducted in an integrated system called syn-gas polygeneration. Syn-gas polygeneration is efficient and environmental friendly. Its process can be conducted gradually. Yet government policy is needed to start applying syn-gas polygeneration from coal gasification.

Key words : energy crisis, polygeneration, gasification, coal, syn-gas, syntetic gas derivates and environmentally friendly.

1. BACKGROUND

Until now, Indonesia is highly dependent on oil. The percentage of national mix energy consumption in 2003 reached up to 54.4% and proportion of various energy consumption in Indonesia can be seen in Figure 1 (Sembiring, S.F., 2005). Table 1 shows reserve of oil, natural gas and coal for both Indonesia and world as well as year estimation when the three energy sources will be expired.(British Petroleum, 2005).

Population and living quality increases result in raising the oil demand as well. Data of the amount of consumption and production as well as ratio of Indonesian oil consumption – production can be seen in Table 2 (British Petroleum, 2005). From the data, it can be predicted that in the years ahead Indonesia will run out of domestic oil supply. As a result, Indonesia will be a net oil importer. Reduction of Indonesian oil supply and increasing of oil price in international market will make energy crisis in Indonesia. It takes for granted that, the government adopts a policy in terms of reducing and replacing it by coal. Consequently, the consumption of national mix energy increases to 32,7% coal, 30,6% natural gas and 26,2% oil in 2025 as seen in Figure 2 (Sembiring, 2005). By the total amount of Indonesian coal (909,064 Giga tons), the energy crisis will be overcome (British Petroleum, 2005).

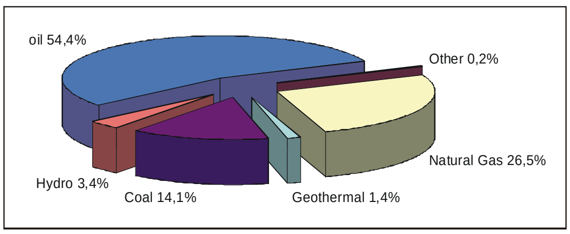

Figure 1. Indonesia mix energy on 2003

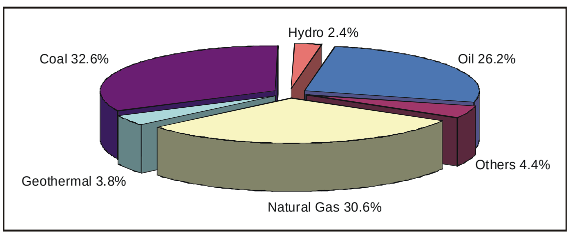

Figure 2. Indonesia mix energy on 2025

Table 1. Indonesian energy reserves in 2004

Proven Reserves	Oil		Natural Gas		Coal	
	Gton	R/P	Tm^3	R/P	Gton	R/P
Indonesia World Total	0.70 161.90	11.50 40.50	2.56 6,337.36	34.9 66.7	4.968 909.064	38 164
Indonesia's share of world total (%)	0.40		1.40		0.55	

Note : $\frac{R}{P} = \frac{reserves}{annual\ \ production} = time\ \ of\ \ reserve\ empty\ \ \text{(year)}$

Table 2. Production, consumption and ratio between production and consumption in Indonesia (billion ton)

Year	1965	1970	1975	1980	1985	1990	1995	2000	2005
Production (P)	24.5	43.1	65.9	79.0	66.3	74.4	76.5	71.5	55.1
Consumption (C)	6.1	6.8	11.4	19.7	22.0	29.8	39.1	50.2	54.7
P - C	18.4	36.3	54.5	59.3	44.3	44.6	37.4	21.3	0.4

There are some serious problems dealing with coal consumption as oil substitute. Those are unfamiliar coal usage by Indonesian, inappropriate technology selection and environmental pollution. Inappropriate technology will cause regional environmental pollution and green house effect. On the contrary, appropriate technology will increase efficiency level and as a result, energy supply will be economized in the future.

This paper discusses syn-gas polygeneration system from integrated coal gasification. Using this polygeneration system, the combinations of coal gasification process will produce synthetic gas (syn-gas) and other various synthetic gas derivation products. All products will be used as oil and natural gas substitute used as either fuel or raw material in chemical industries. The products of this system are easy to use, economical, and environmental friendly.

2. SYN-GAS POLYGENERATION : A WORLD TREND

Decreasing world's supply of oil fuel causes difficulties to guarantee a continue supply of the oil. This will influence the world's oil price that increased up to US$ 60/barrel in the mid-year of 2005 (Republika, July 13, 2005). Such a condition is an advantage for coal usage. As an energy source, it can guarantee the supply and is more economical. Unlike the conventional coal burning that retains low efficiency and produces many pollutants, coal gasification technology can convert 95% of coal into a synthetic gas (syn-gas). Such gas is easy to burn. Syn-gas composition is mostly the mixture of carbon monoxide (CO) and hidrogen (H_2).

Syn-gas polygeneration is a conversion process from coal into synthetic gas and then is converted into other derivates in an integrated system (Hui, 2004). By this system, production cost will be lower compared to conventional process by electric generated and other production operated separately. The main component in this polygeneration system is the gasification technology that has developed rapidly and has been commercialized in several countries such as South Africa, Germany, the United State of America and China (Gasification database, 2004). Synthetic gas can be used as a substitute of natural gas for an efficient electric generator using integrated gas turbine combine cycle (IGCC) technology or integrated gasification fuel cell (IGFC). It can also be used as raw materials for the making of various chemical industries materials and synthetic liquid fuel such as hydrogen (H_2), ammonia (NH_3), methanol (CH_3OH), dimethyl ether or DME (Williams, 2001). Using a

Fisher-Tropsch reaction, the gas can be converted into gasoline and diesel that is known as gas to liquid (GTL) technology. Such a technology may be applied in a commercial scale (Headwater Technology Innovation Group, 2004).

As syn-gas polygeneration system produces high purity synthetic gas and other derivates, CO_2 emission which comes from the system is easier to be separated and purified. As a result, There are two advantages, namely decreasing pollution effects (green house effect) and gaining economical CO_2-by products (Simbeck, 2001).

A case study about the application of polygeneration system is in China. It was written in vision of modernized coal as seen in Figure 3 (Task Force on Energy Strategies and Technologies, 2003). Vision of modernized coal polygeneration was based on the process of gasification, whereas the further development is divided into two parts that is near-medium term polygeneration (2006 – 2020) and long term polygeneration (^{3} 2020). Using this system, the coal will easily be converted into electricity generator, steam, and other derivates that is used as energy sources and integrated chemical materials. In a near-medium term polygeneration, the facility to produce town gas, methanol, F-T liquid and DME is built as an electricity generator co-product. The market to be supplied by this system is:

- urban communities for cooking and room heater purposes by utilizing town gas as a substitute for coal;
- rural communities and small cities for the needs of cooking using DME from coal gasification and biomass;
- industrial fields by applying city gas as heat source (steam);
- transportation fields without adding new infrastructure. It consumes gasoline- mixed methanol or known as gasohol and diesel fuel- mixed F-T liquid;
- transportation fields by adding new infrastructure and utilize DME. In the beginning, it was only applied for busses and trucks and then also applied for cars.

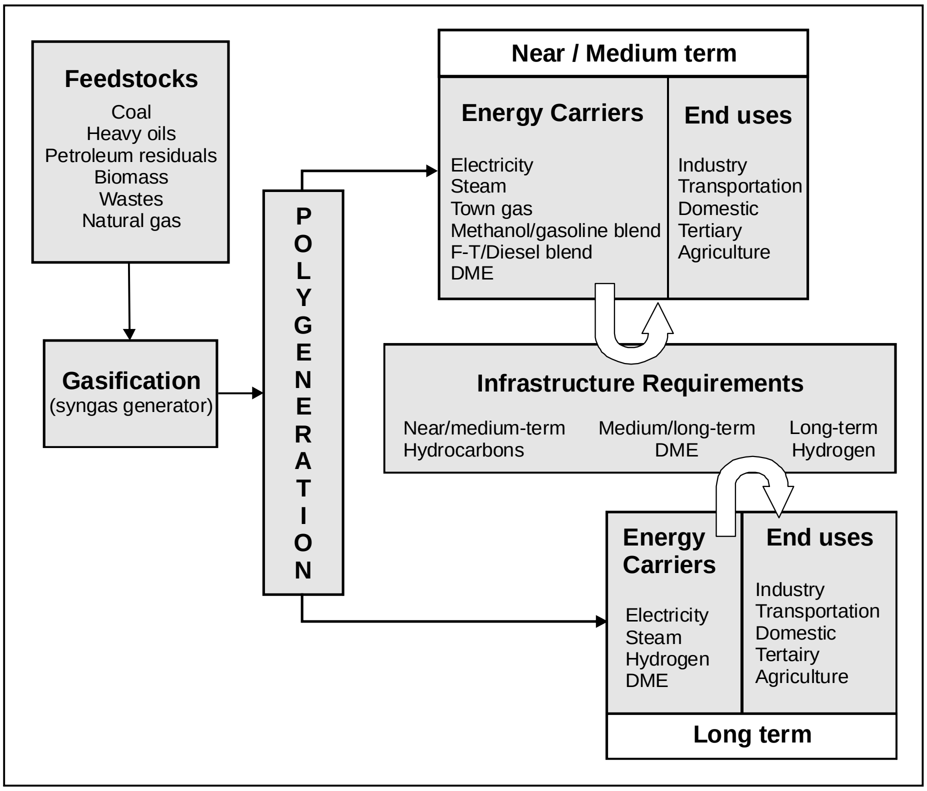

Figure 3. Vision of modernized coal

Dealing with the long term polygeneration that is related to green house effect issue, every country must develop environmental friendly materials such as hydrogen and electric energy. Both hydrogen gas and electricity energies can be produced by syn-gas polygeneration system. Separating and purifying CO_2 is cheaper when using polygeneration system. Hydrogen is utilized for urban areas whereas the rural areas still utilize environmental friendly carbon-based fuel like methanol, DME, and F-T liquid.

3. SYN-GAS POLYGENERATION MODEL

A model of syn-gas polygeneration can be adopted from the concept developed by Li Zeng (2003). This model retains high flexibility, integrated energy resources, industrial world and environmental conservation. Figure 4 illustrates polygeneration system slot. The figure merely shows a model of the development of the system from coal gasification. Details discussion regarding mass and energy balances and target (technology, economical analysis, energy resources exploitation and environmental aspects) of each subsystem will be optimized in a further study. The main point in the polygeneration concept is as follow :

a. applying lignite as raw material (such a material is relatively abundant in Indonesia). Coal gasification technology applied here is circulating fluidized bed gasification that uses steam reactor. This technology is appropriate for low rank coal as due to its high efficiency. The produced syn-gas is high purity CO and H_2. (Kubota, 2006). Sulfur is obtained as a by product;

b. syn-gas product can be converted into various materials, such as:

- town gas as natural gas and LPG substitutes for domestic and small to middle scale industries purpose;
- large scale electricity generator material produced by integrated gas turbine combine cycle (IGCC) or integrated gasification fuel cell (IGFC) technologies;
- hydrogen as raw material for chemical industries and fuel cell for electricity generator and even vehicle fuel. Cars using hydrogen as fuel are suitable to be used in big cities as emissions are near to zero;
- methanol and di-methyl ether (DME) as liquid fuel can substitute gasoline and as industrial fuel replaces petroleum and die-

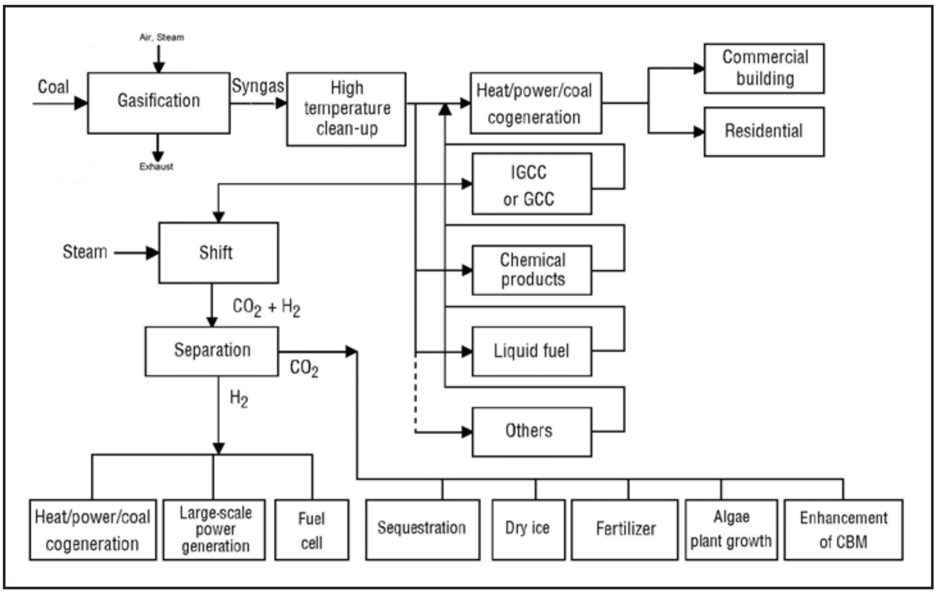

Figure 4. A flow chart of polygeneration system

sel fuel and also as raw materials is used in chemical industries;
- synthetic gasoline and diesel fuel from Fisher-Tropsch reaction or known as gas to liquid (GTL) technology. The material retains low sulfur and fits for vehicle in the future (Yoediartiny and Anwar, 2004); other chemical materials such as ammoniac, urea and distillate hydrocarbon; rocarbon destilats;

c. preparation and exploitation of CO_2 emission. Syn-gas burning will produce less pollution compared to conventional coal burning. This, in turn, will reduce the green house effect - the current and actual global issue. In syn-gas polygeneration system, separating CO_2 emission is easier. The gas is almost pure, near 99% (Ni Weidou, et.al., 2000). Unlike conventional coal burning, in which CO_2 emission is mixed in a large amount with another particulate and another gas such as hydrogen, syn-gas burning is simpler and CO_2 content is larger. Therefore, it is easier and cheaper in separating and purifying the CO_2. Separated and purified CO_2 is a by-product material and can be used as raw materials for chemical industries. The material is also used to extract methane from coal. In fact, such a material is difficult to be exploited as its location is available on the offshore. This technology is known as coal bed methane (CBM). Methane within coal pores is extracted by injecting CO_2 gas. This is due to coal absorption capacity towards CO_2 is higher than that of methane gas. As a result, the methane gas comes out from the coal pores and is replaced by CO_2;

d. closed inter-coupling in production process (CIPP). For example syn-gas that does not react in methanol-making reactor can be used directly to accomplish IGCC need. This means that the subsystem of methanol production does not require the addition of syn-gas recovery unit as usually occurs in conventional methanol reactor. As a result, it will significantly minimize financial capital, operation cost, and environmental pollution. This, in turn, will be lessening production cost;

e. opened and flexible system. Depends on national needs, syn-gas polygeneration system can be implemented gradually to the available polygeneration product and investment. For example, step 1 is constructing a gasifier plant to produce town gas. Step 2 is establishing electricity generator to produce hot steam. Next step is installing another unit to produce methanol, ammoniac, urea, hydrogen and other products.

4. SYN-GAS POLYGENERATION ADVANTAGES

Profit calculation of syn-gas polygeneration system is based on coal-based production separated of electric and steam power stations, methanol coal and syn-gas. Each production retains capacity of 400 MW (Ni Weidou, et.al., 2000). Figure 5 (the left side) shows economic comparison between electric and steam power stations that are established separately, cogeneration between electric and steam power stations and cogeneration using IGCC technology. Electric and steam power stations that are established separately produce electric power for 3.36 and 1.5 cent/kwh respectively. Cost of cogeneration between electric and steam power stations is 3.06 and 1.5 cent/kwth respectively. For IGCC technology, the product cost is 2.44 and 1.5 cent/kwth respectively. The right side of Figure 5 shows the economical comparison between the electricity and steam generators, and methanol production as well. If using GCC-steam cogeneration and methanol production separately, the methanol price is 12 cent/liter. However, if using integrated IGCC, steam and methanol production, the methanol cost can be reduced to 7 cent/liter but the cost of other product it still the same. Therefore, the total cost reduction is 40%.

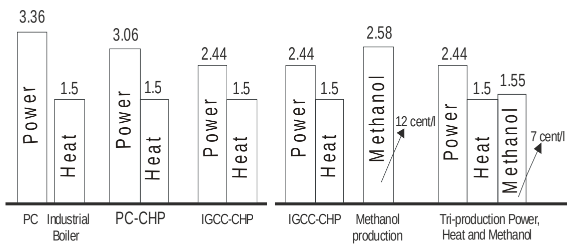

Figure 5 **Economic comparison between electric and steam power stations (left) and electric, steam power stations and methanol production (right)**

Figure 6 shows economical comparison between electricity generator, steam, methanol production and syn-gas. If syn-gas production is established separately, the output is $ 4.8/GJ whereas the integrated system will provide output of $ 2.6/GJ. The different of syn-gas production scale is the cause. In general if compared to the separate production, the integrated production of the four products provide advantages, namely deducting of investment and production costs, and coal usage into 38%, 31%, and 22.6% respectively (Figure 7).

5. CONCLUSIONS AND SUGGESTIONS

Syn-gas polygeneration system from coal gasification is suitable to be implemented in Indonesia. One of system advantages is the abundance of coal as raw material in Indonesia. This can guarantee national energy supply for a relative longer time. The polygeneration system is efficient in consuming coal as raw material so it is more economical.

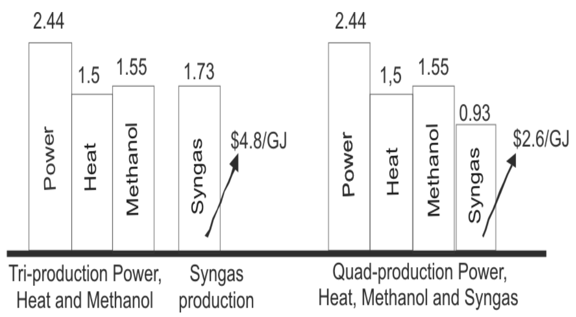

Figure 6. Economic comparison for the production of syngas, electricity, heat and methanol

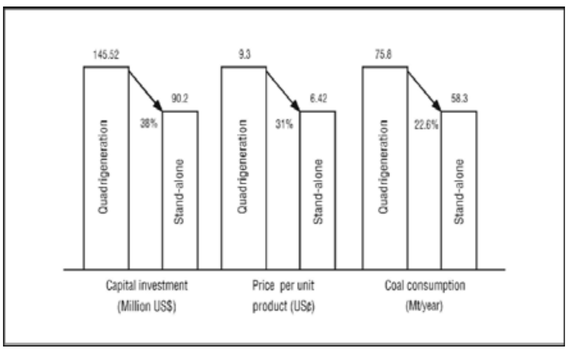

Figure 7. Reduction of investment and production costs and coal consumption as well

Syn-gas polygeneration system produces many syn-gas derivates as energy sources and raw materials for chemical industries that can substitute oil and natural gas. Syn-gas application will guarantee continue energy supply and raw material for chemical industries.

Established gradually, investment for syn-gas polygeneration is relatively low. Therefore, it needs to establish continually polygeneration. Syn-gas polygeneration system is environmental friendly. Development in fuel cell technology makes the system promising. It yields not-polluted energy source.

Supports and coordination from various sectors are required when establishing syn-gas polygeneration system. R and D Center for Mineral and Coal Technology collaborates with other institutions must be able to make a master plan related to such a system as currently conducted with Ishikawajima-Harima Heavy Industries Co., Ltd., Japan.

As coal exploitation is a global issue today, in terms of developing clean coal technology, financial and other support from international institutions, such as UNDB, World Bank, Asian Development Bank, and GEF are absolutely required.

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